



### **Subject: Are hydrogen fuel cells useful?**

**General goal:** information on the advantages (and difficulties) related to the use hydrogen fuel cells

#### **Specific goals (knowledge):**

- hydrogen fuel cell as inverting of the electrolysis
- processes in hydrogen fuel cell: dissociation of  $H_2$ , catalytic ionization ( $H \rightarrow H^+ + e^-$ ), diffusion of proton through the membrane, formation of  $H_2O$  on cathode, electric current (electrons) through the external circuit
- crucial elements of FCH: catalyst, polymeric membrane
- direct burning fuel has low thermodynamic efficiency (<30%) while FCH theoretically arrive to 80%

#### **Specific goals (social competences):**

- advantages of FCH in urban transportation – no nitrogen oxides, no noise, no benzene compounds
- advantages of “distributed” hydrogen economy – producing  $H_2$  at household, storage, re-fuelling
- at present FCH technology is expensive, but it was always like this with any invention, including Volta’s pile (made of Ag and Sn)

#### **Experimental equipment:**

- hydrogen car model
- PV cell for charging
- Voltmeter with wires and crocodile clips

#### **Working methods:**

1. Lecture by the teacher and/or FCHGo staff, and answering questions (1 lesson unit)
2. Demonstration of fuel cells (Hydrogen car, Horizon station, Ethanol cell [1] – what is available) and simple experiments: i) charging voltage (and current) from the PV panel, ii) voltage and current delivered by FCH at zero load, iii) if possible – power consumption (what is the maximum inclination angle that the car still goes up) (1/2 lesson)
3. Discussion with students and resumé (1/2 lesson)

## Forms of work

- panel lesson (45 minutes)
- hands-on activity and discussion (45 minutes)

## Lesson scenario (2x45 minutes)

Teacher activity	Student activity
<i>Introduction</i> (10 minutes)	
“We already know that environment questions are important. Today we treat in detail the economical and technological questions of FCH”	
- Introduction (10 minutes) <ul style="list-style-type: none"> <li>• What are the most important issues in environment?</li> <li>• What can be done to avoid global pollutions?</li> <li>• Does it solve the problem of urban mobility?</li> <li>• What are the costs of electrical cars?</li> </ul>	- Global (i.e. CO <sub>2</sub> ) pollution, local (benzene derivates) pollution - alternative, renewable “energies” - local pollution must be solved differently - lead batteries are heavy (and Pb is poisonous); lithium batteries are expensive
<i>Main activity</i> (35 minutes)	
- Teacher shows presentation “Fuel cells” [2] dealing with : <ul style="list-style-type: none"> <li>• Invention and general idea of hydrogen reversed electrolysis</li> <li>• Details of functioning (elementary processes) of FCH</li> <li>• Details of construction of FCH</li> <li>• Prototype applications</li> </ul>	- Students make notes, and photos (FCH scheme)
Break (10 minutes) – possible observing the equipment	
<i>Laboratory activity</i> (25 minutes)	
- Simple hands-on experiment with FCH model car: running with PV cell only, charging of FCH from PV panel, observation of gas accumulation, running the car; possible simple electrical measurements (current and voltage – make attention on correct connection)	- students assist the experiment, possibly participating in small function (“please, fix the voltmeter to measure the current”, “please, bring the lamp closer to the PV”, “please, rise the table on one side by 5 cm and we will check if the car is still able to climb the slope”
- work in pairs: “make a quick drawing what we have done” (3 minutes)	- students discuss and compare their observations

<i>Conclusions (15 minutes)</i>	
<p>- Questions:</p> <ul style="list-style-type: none"> <li>• What have you learned today?</li> <li>• What is the main environment problem that FCH can solve?</li> <li>• Why this technology is still expensive?</li> </ul>	<p>- Student answer in a linear order: everyone must acquire the ability to argue the basic questions.</p>
<p>Question to be answered individually by pupils (after the lesson): “Do you think that FCH technology will be in use in next 5/ 10 years?” “How is your town/ country placed in this technology race?”</p>	<p>-Students discuss independently after the lesson. The teacher <i>does not</i> ask their opinions.</p>

#### Home work

- Find in internet possible applications of FCH

- Search for more professional information on FCH efficiency (blog discussions, scientific papers, political declarations etc.)